National Weather Service
Alaska-Pacific River Forecast Center
http://aprfc.arh.noaa.gov

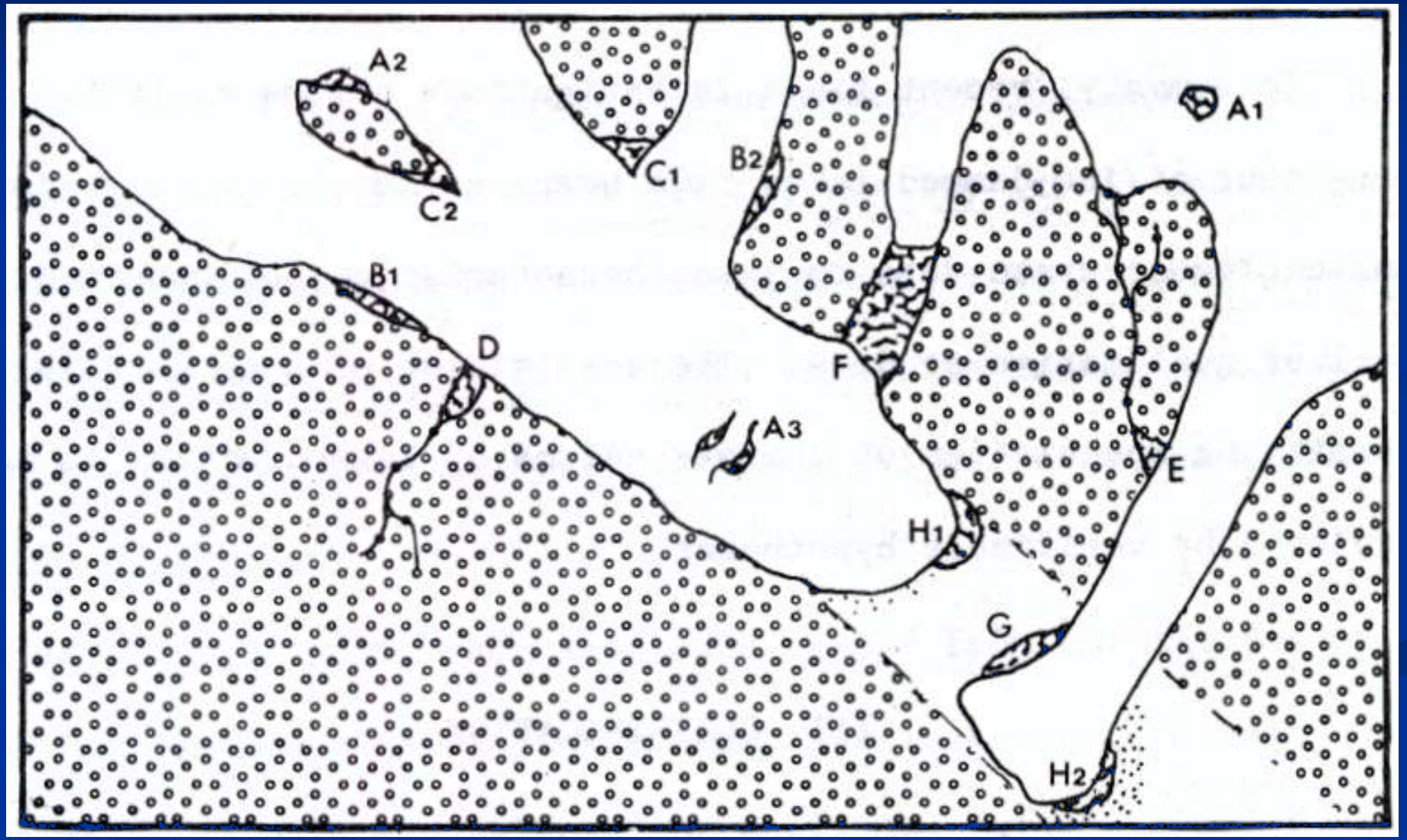
Glacier-Dammed Lakes in the Kenai River Basin

Presented at Kenai River Center in November 2007

Definitions

- A glacier-dammed lake is a substantial body of standing water located in, on, under, or at the margin of a glacier such that its existence is in some way dependent on damming by glacier ice
- Glacier-dammed lakes are locally referred to as potholes
- The rise in water level in streams down valley due to the draining of a glacier-dammed lake is often referred to by the Icelandic term “jokulhlaup”

Types of Glacier-Dammed Lakes
750 Lakes Mapped in Alaska in 1971



Cycle of Glacier Dammed Lake Releases

- Lake filling
- Release trigger
- Partial release possible
- Tunnel or channel growth
- Lake draining until empty
- Tunnel closure

Note that the glacier dam does not suddenly break apart

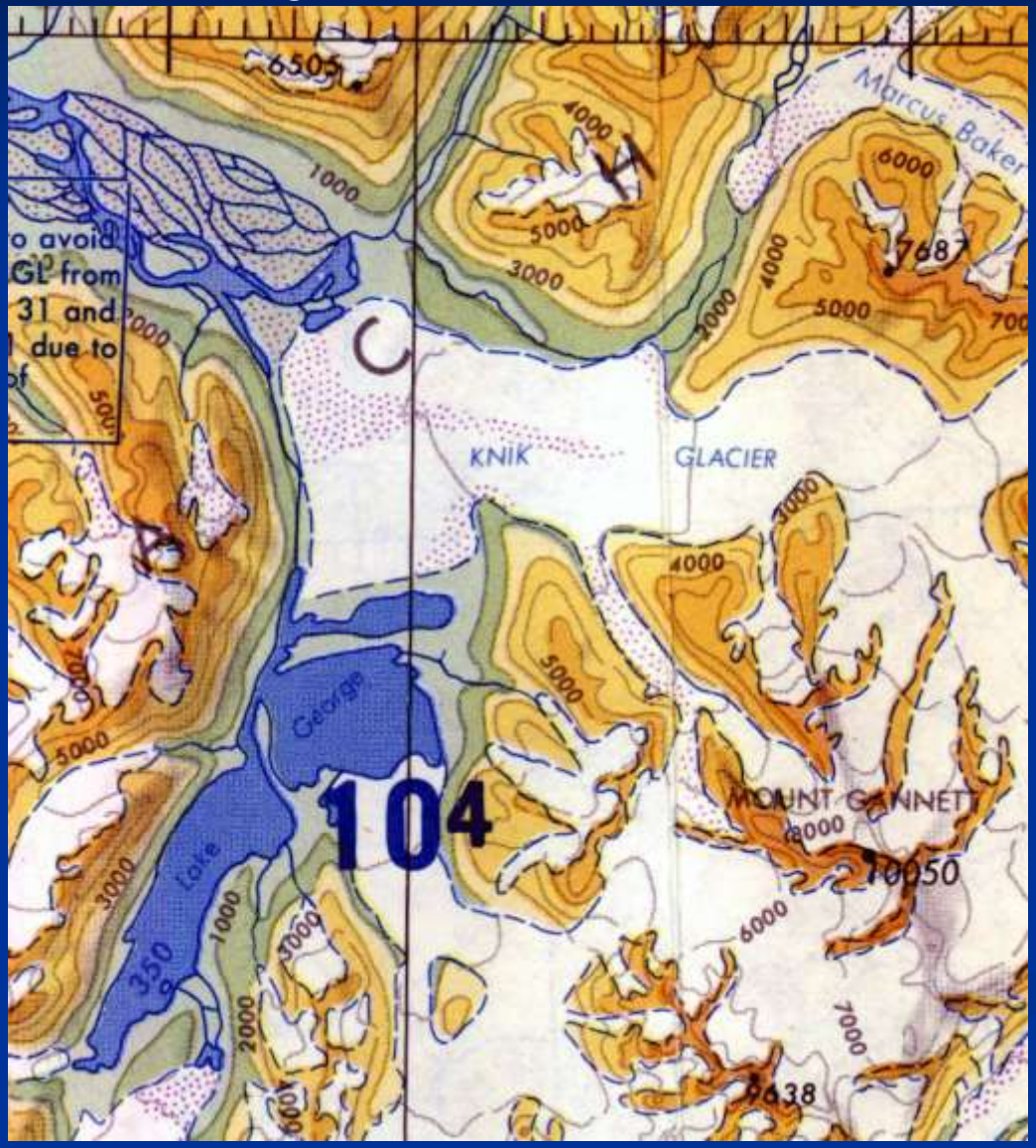
Release Triggers (Pulling the Plug!)

List of mechanisms by Post and Mayo (1971)

- Raising of the ice dam by floating
- Water overflowing the dam along margin
- Slow plastic yielding of the ice
- Progression of cracks in the glacial ice
- Drainage through small preexisting channels
- Weakening of the dam by earthquakes
- Sub-glacial melting by volcanic heat
- Combination of triggers

Lake George - Lateral Release

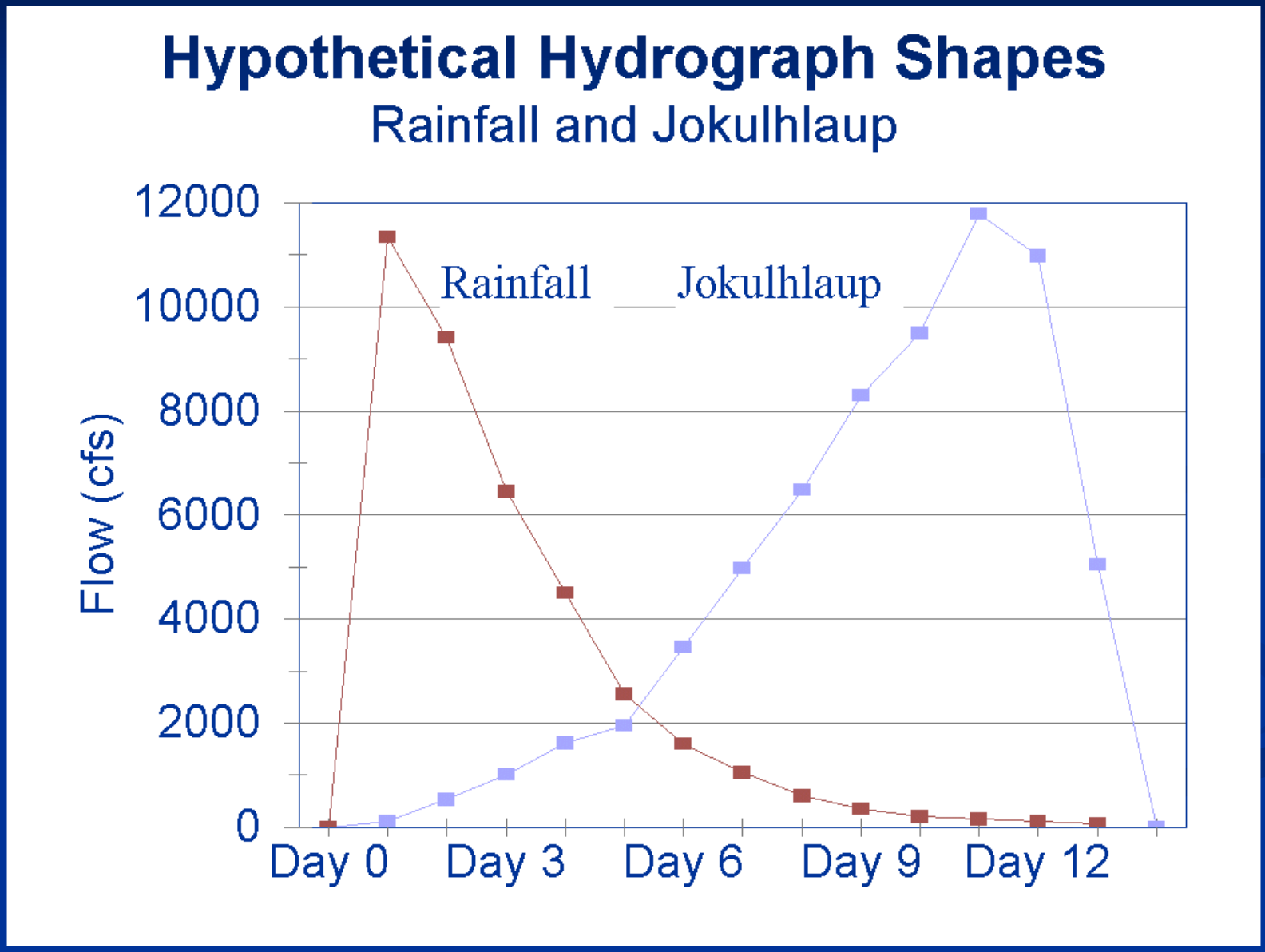
Similar configuration has caused Hubbard Glacier to block Russell Fjord near Yakutat



Tunnel Growth and Closure

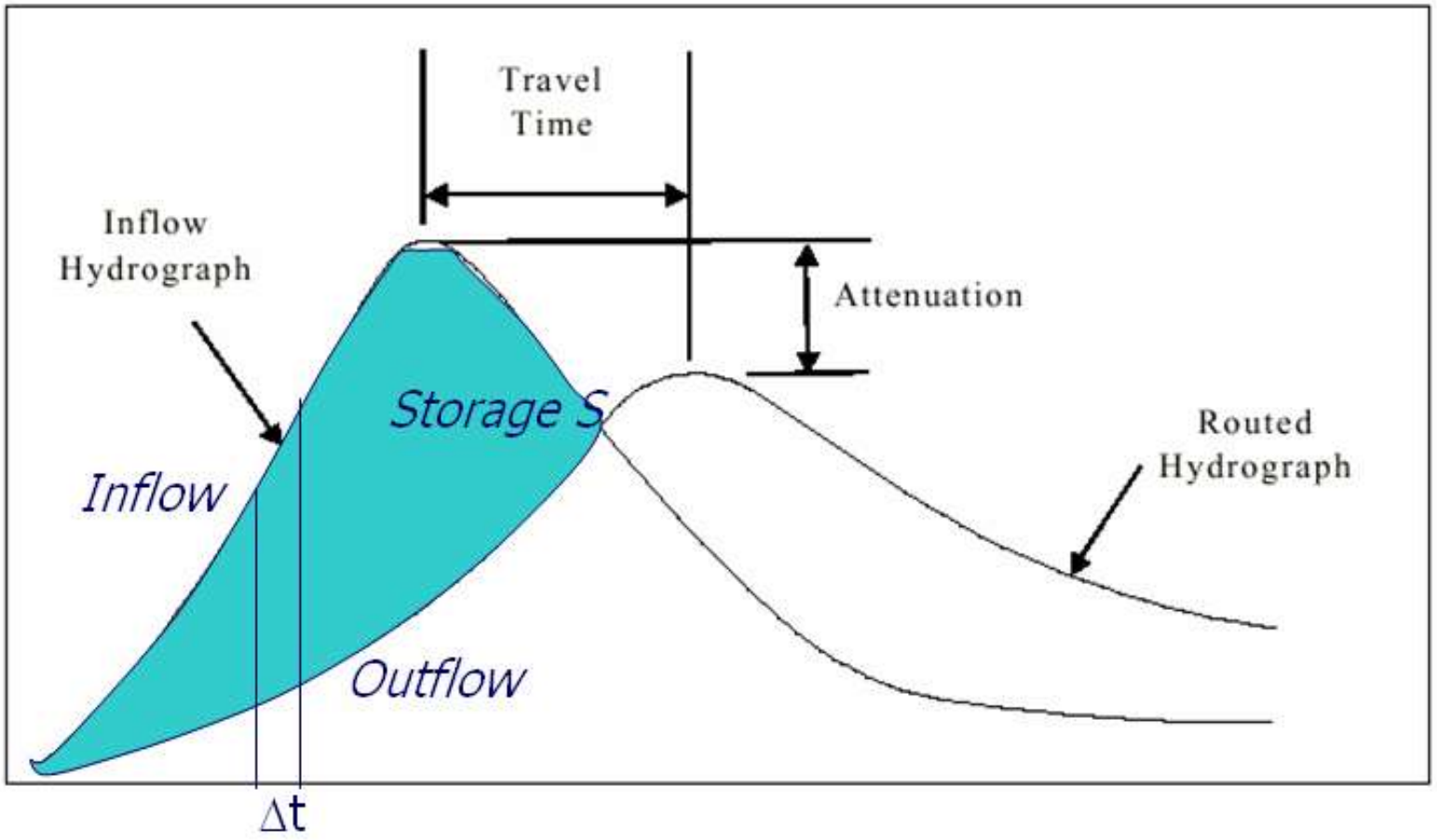
- After the leak is established, the outflow tunnel or channel enlarges rapidly by melting
- Size of tunnel or channel is related to the volume of water that has already passed through it
- The lake level decreases to a point where the outlet stops growing, but the plastic flow of the glacial ice is too slow to close the outlet before the lake empties
- When lake has emptied, tunnel or channel will slowly close due to plastic flow of the glacial ice

Jokulhlaup Hydrograph

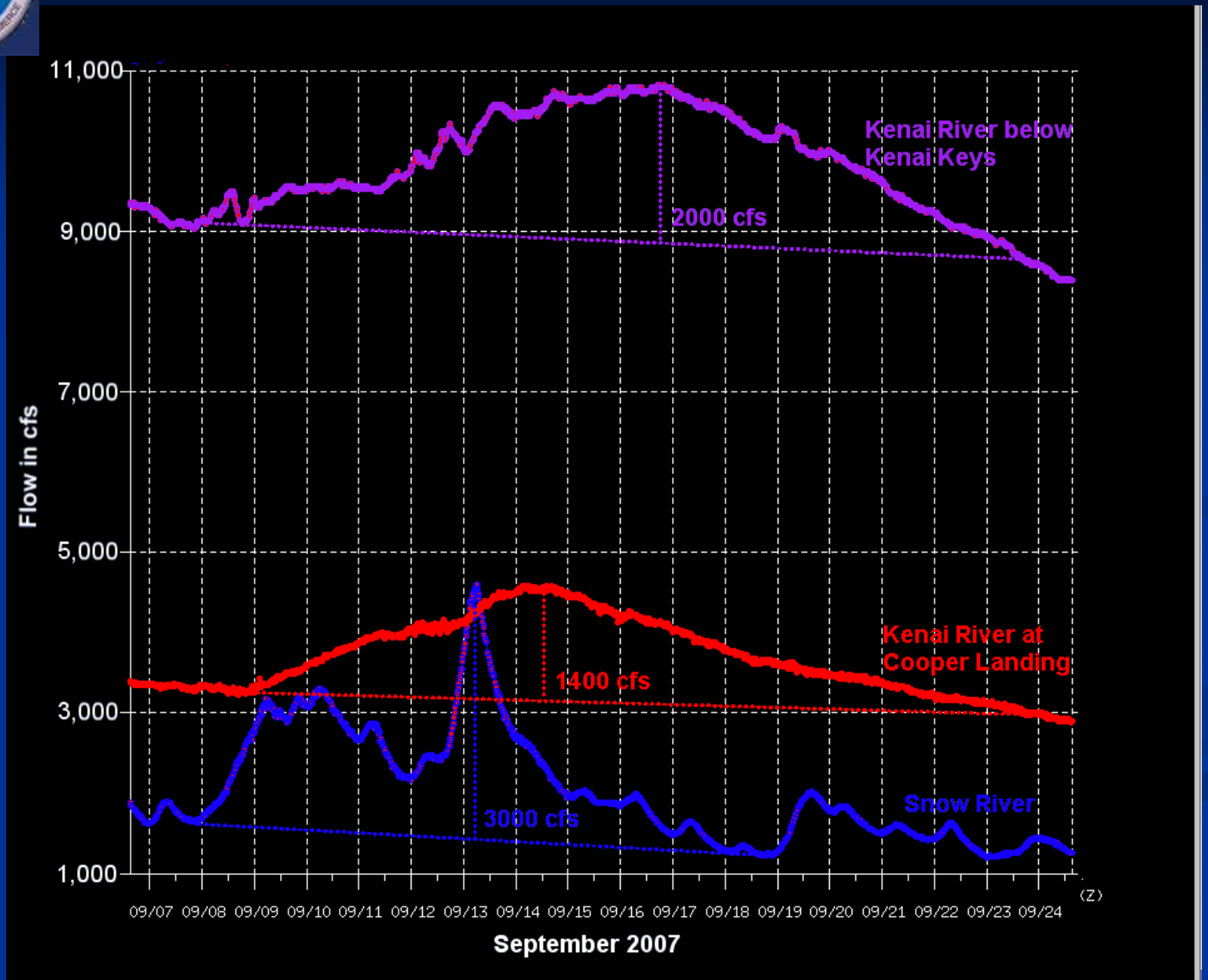


River Routing Concept

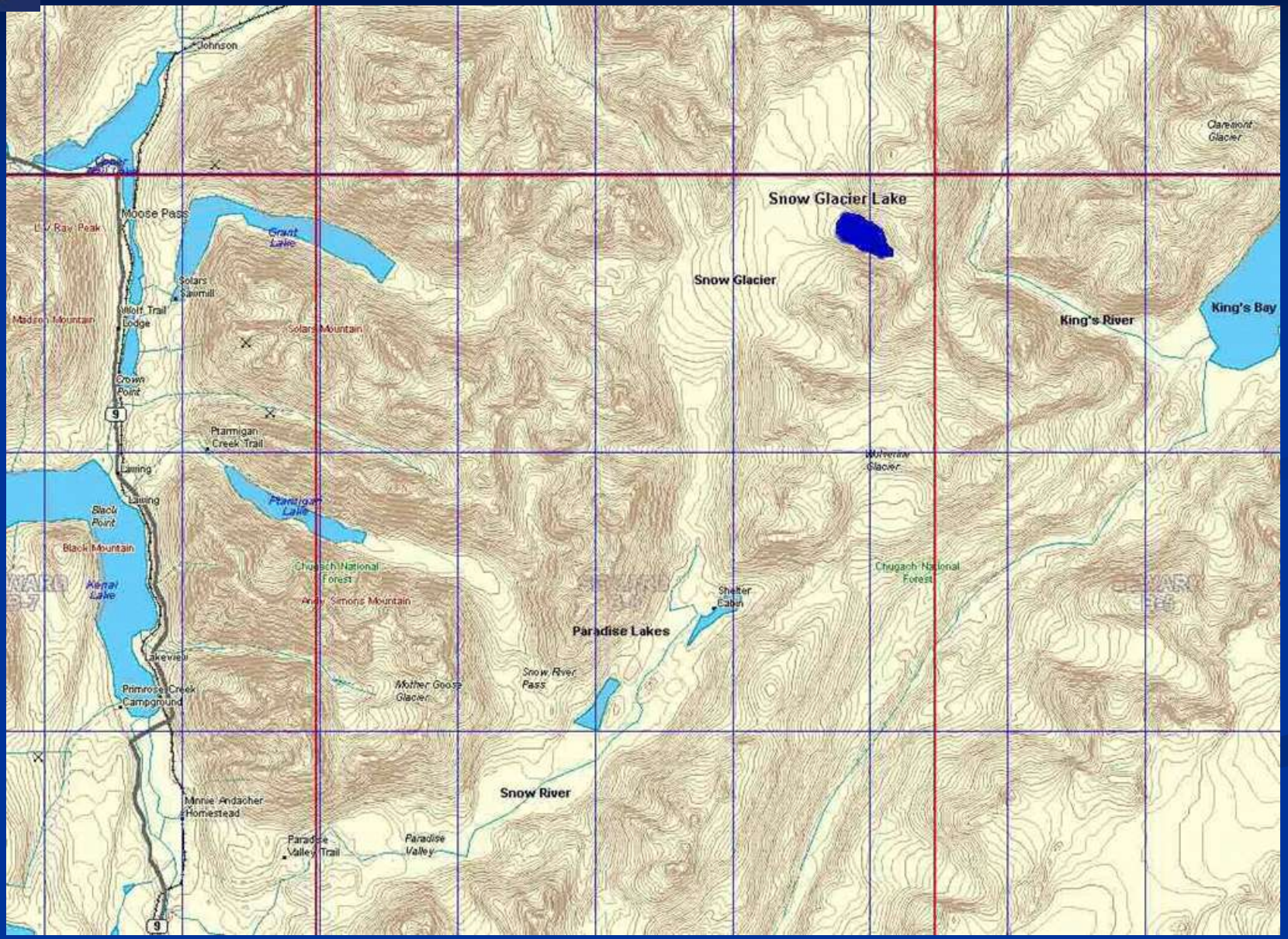
Avg Inflow - Avg Outflow = dS/dt



Kenai River Rain Event Routing



Snow Glacier-Dammed Lake

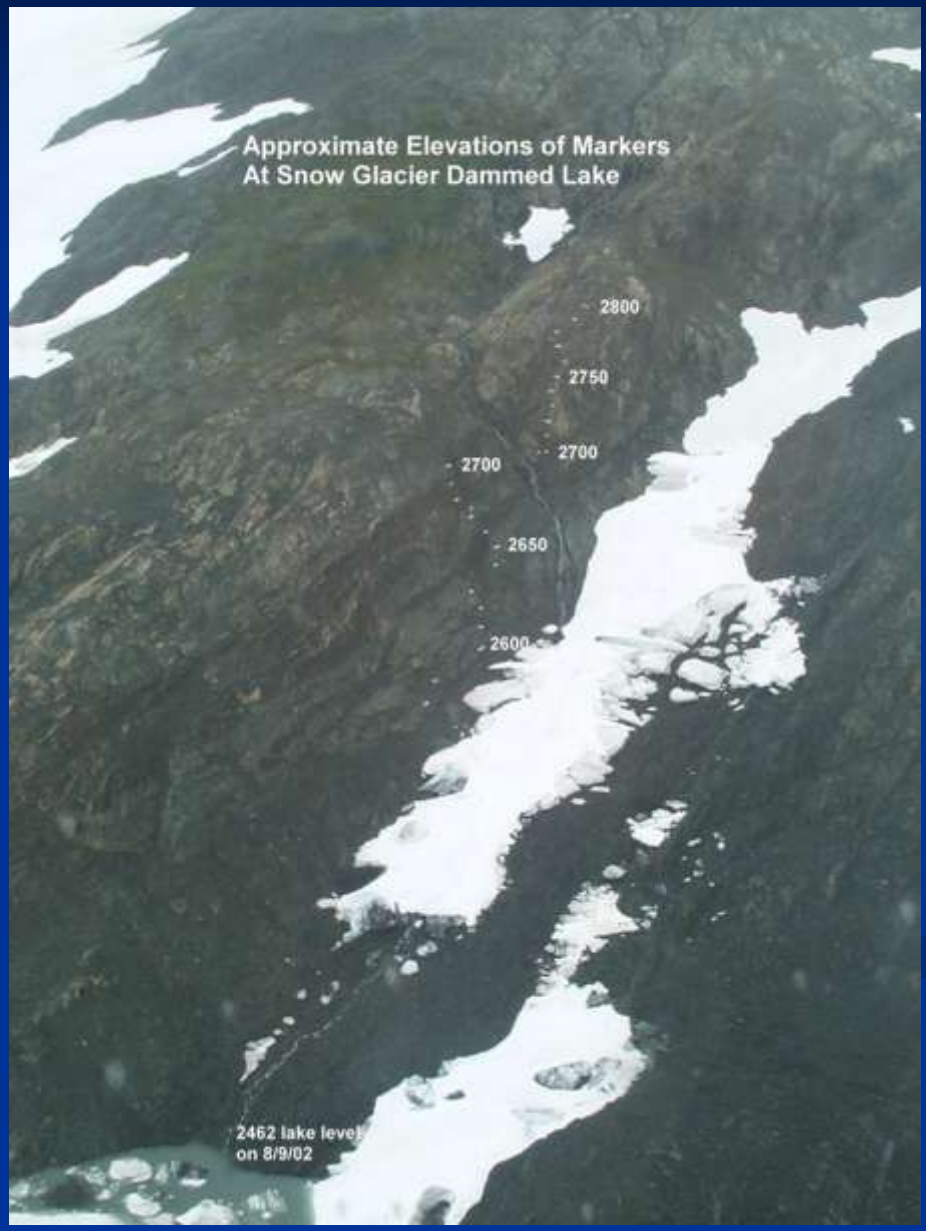


Snow Glacier-Dammed Lake

- Snow glacier dammed lake volume is 100,000 – 150,000 acre-ft
- Equivalent to 15-22 inches of rain over entire Snow River basin
- Maximum depth 300-400 feet
- Takes 1-2 weeks to drain
- Causes 3-5 foot rise on Kenai Lake

Glacier-Dammed Lake Monitoring

Conduct aerial overflights to monitor lake levels... more frequent monitoring when lake level approached spill levels



Snow Glacier Dammed Lake Schematic

Kenai glacial lake ready to unleash billions of gallons

Jokulhlaup (pronounced yokel-lop) is an Icelandic term describing sudden water releases from glaciers or glacier-dammed lakes. They occur on glaciers around the world and vary immensely in size. There are about 750 glacier-dammed lakes that can generate jokulhaups flowing into streams around Alaska. Jokulhlaups recur at intervals ranging from several months to several years.

Snow glacier-dammed lake

LENGTH: One mile
WIDTH: 3/4 miles
DEPTH: 400 feet at deepest point
ELEVATION: 2,700 feet
ESTIMATED VOLUME: 39 billion gallons of water or about 3,500 Exxon Valdez oil spills

What happens

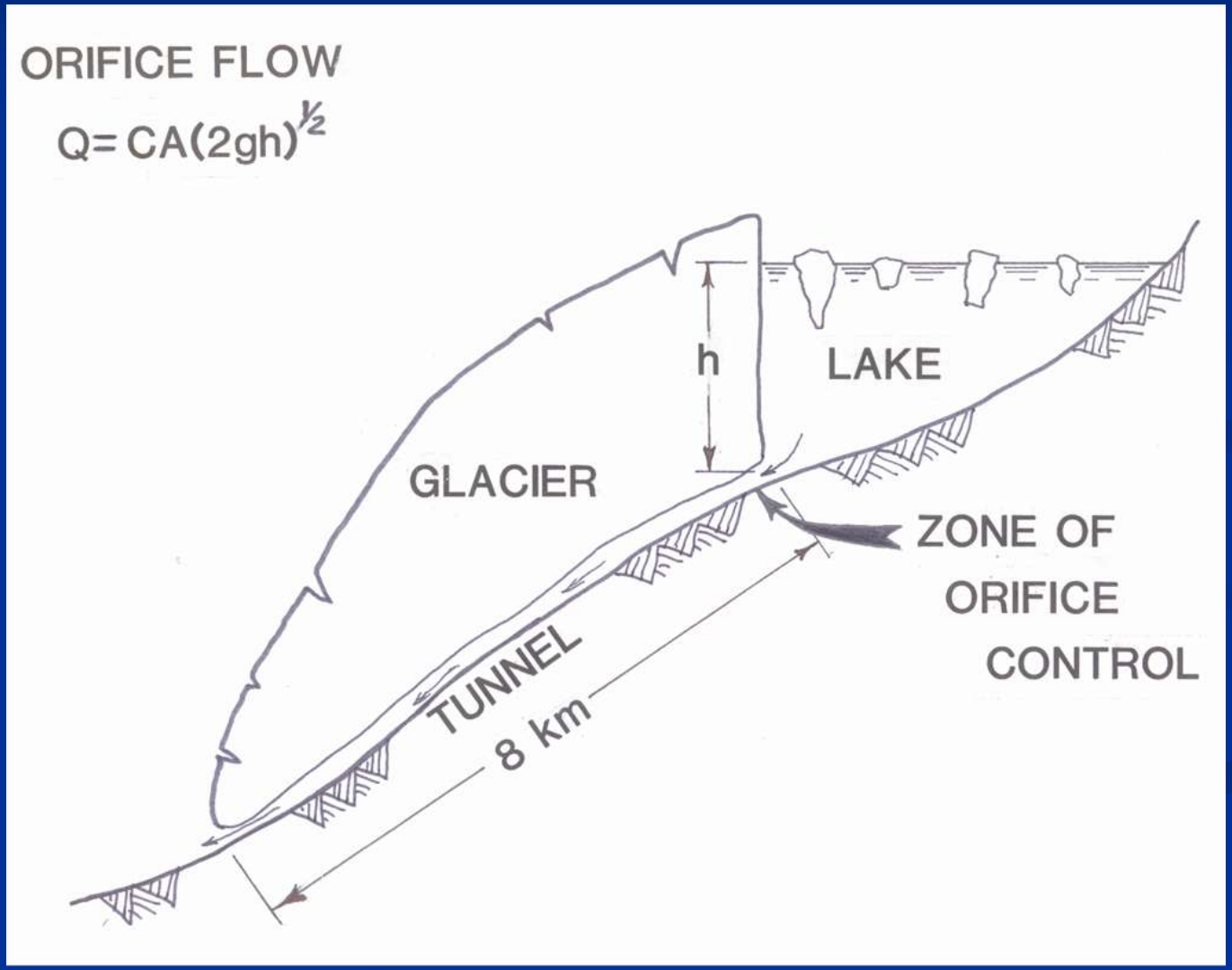
1. Rain, ice and snowmelt fill a lake basin in a side valley which is dammed by the glacier
2. The pressure of the filling lake lifts the glacier dam up allowing lake water to develop and enlarge an outlet through the base of the dam
3. Escaping water moves through tunnels developed from summer glacial melt
4. Lake water flows from glacier at its terminus into Snow River.
5. After the lake has completely drained the glacier settles and the outlet slowly closes blocking the escape of additional water and the process then repeats itself

Source: USDA Forest Service, Alaska Region, Alaska River Forecast Center, National Weather Service

RON ENGSTROM / Anchorage Daily News

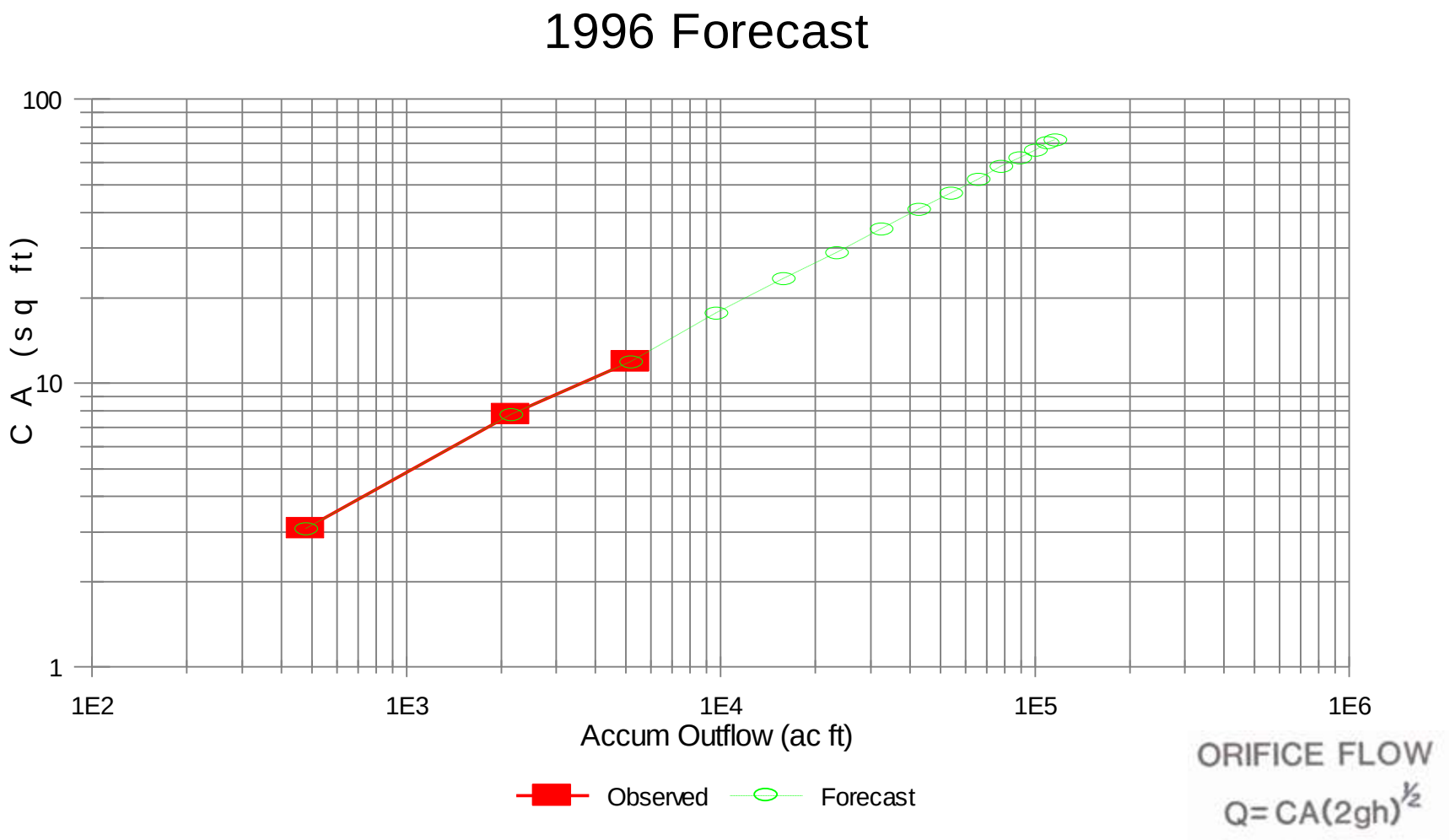
Jokulhlaup Model

Developed by David Chapman in the 80's



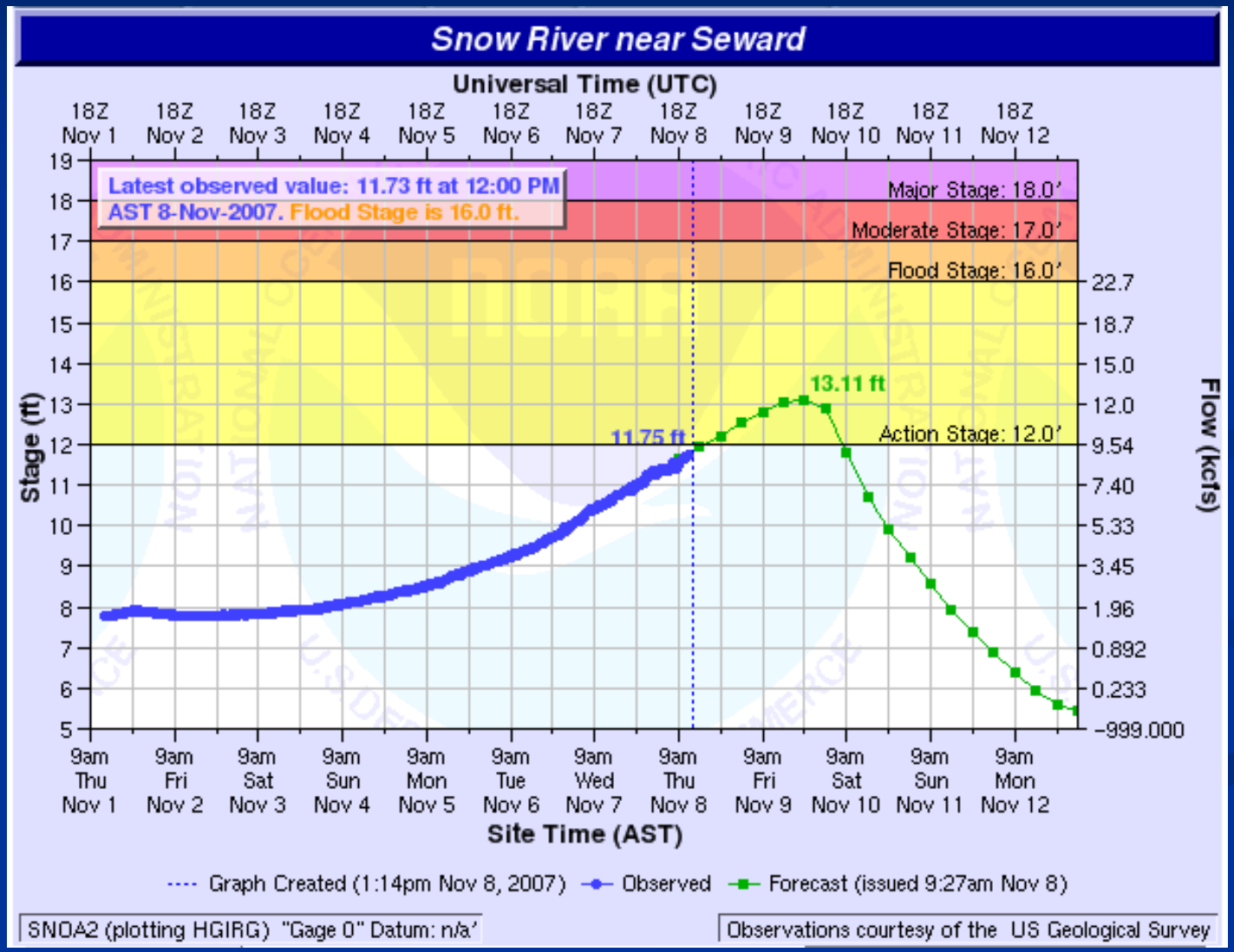
Forecast Process

Slope of line determines Jokulhlaup shape... it is tuned daily based on additional data



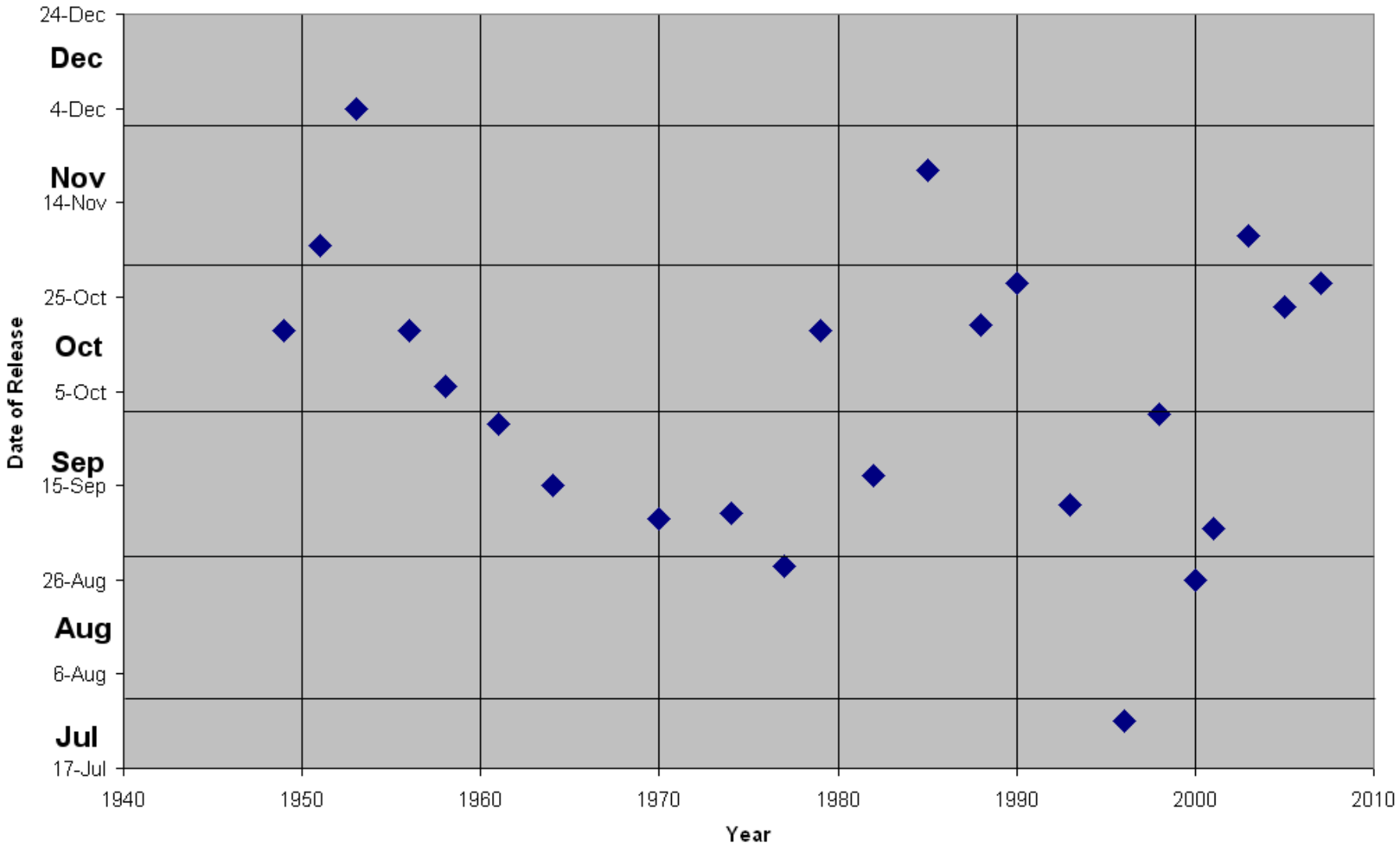
Forecast Process

Model output determines Jokulhlaup shape... allowing NWS to forecast hydrograph



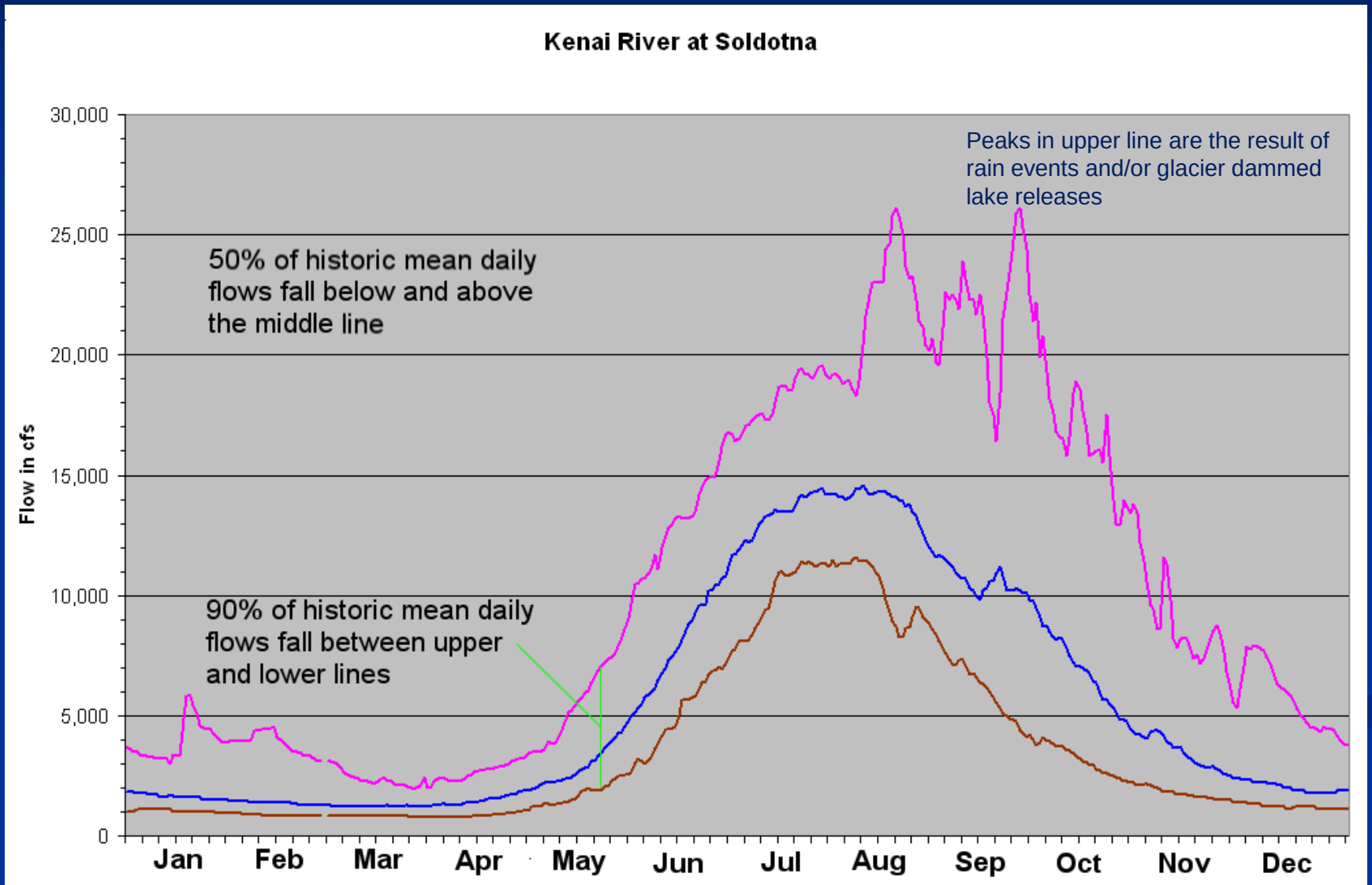
Snow GDL Release Timing

Releases between 1911 and 1949 were often in November, December, or January

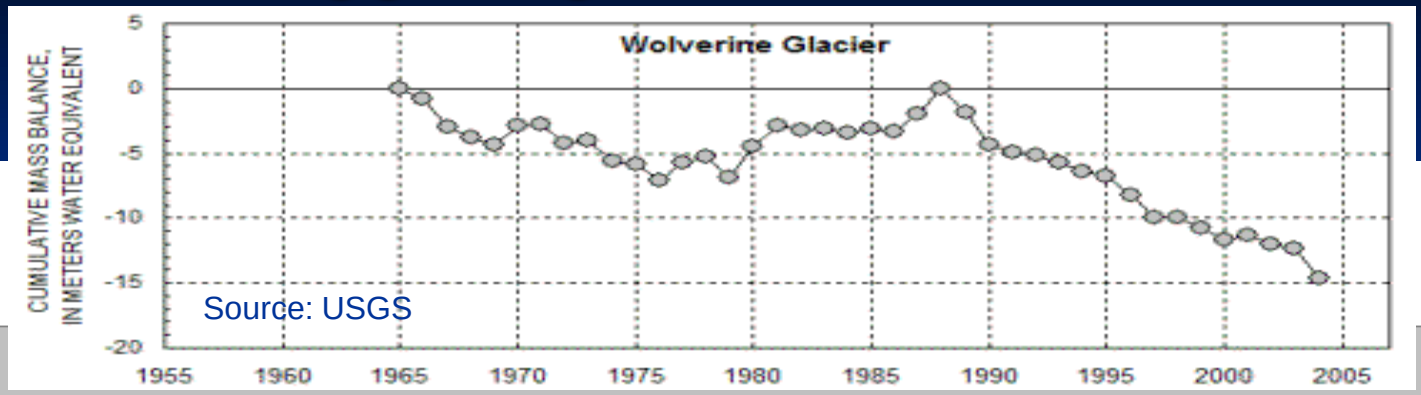


Glacier Dammed Lake Release Timing

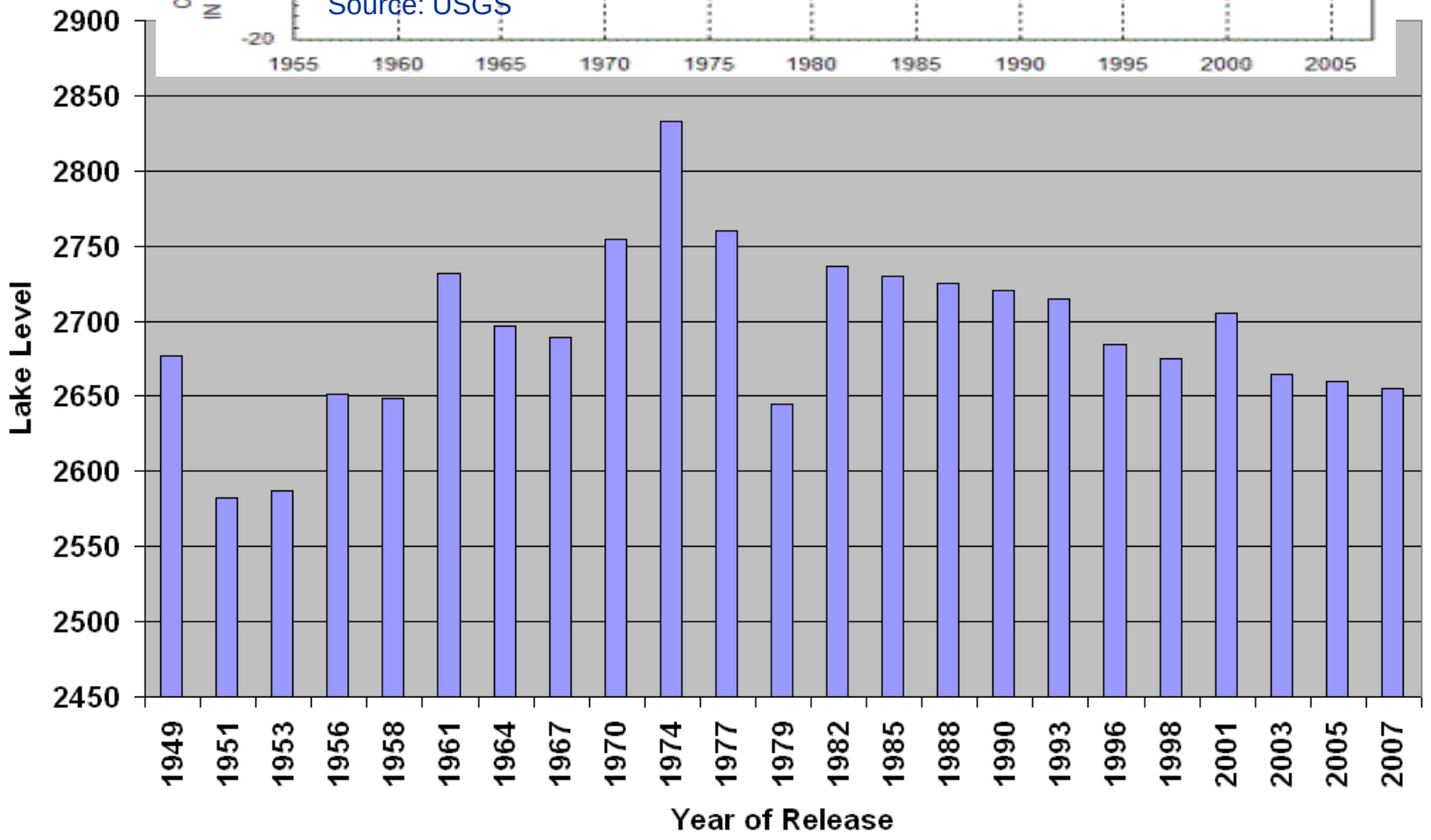
Mean daily flow statistics for the Kenai River at Soldotna based on 41 years



Triggering Lake Level

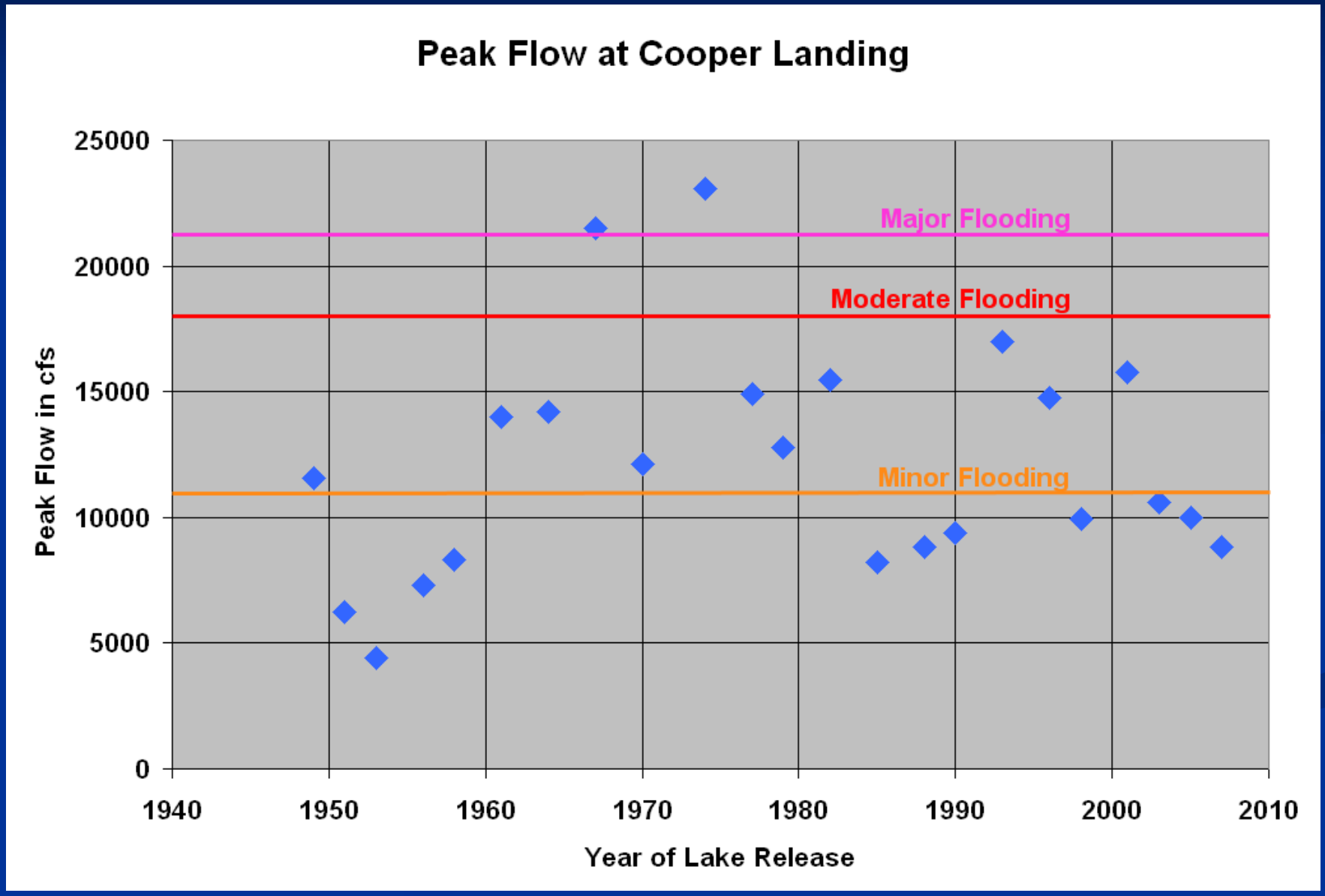


Source: USGS



Impact of Jokulhlaup

Kenai Lake attenuates peak - most flood impacts are due to high Kenai Lake levels

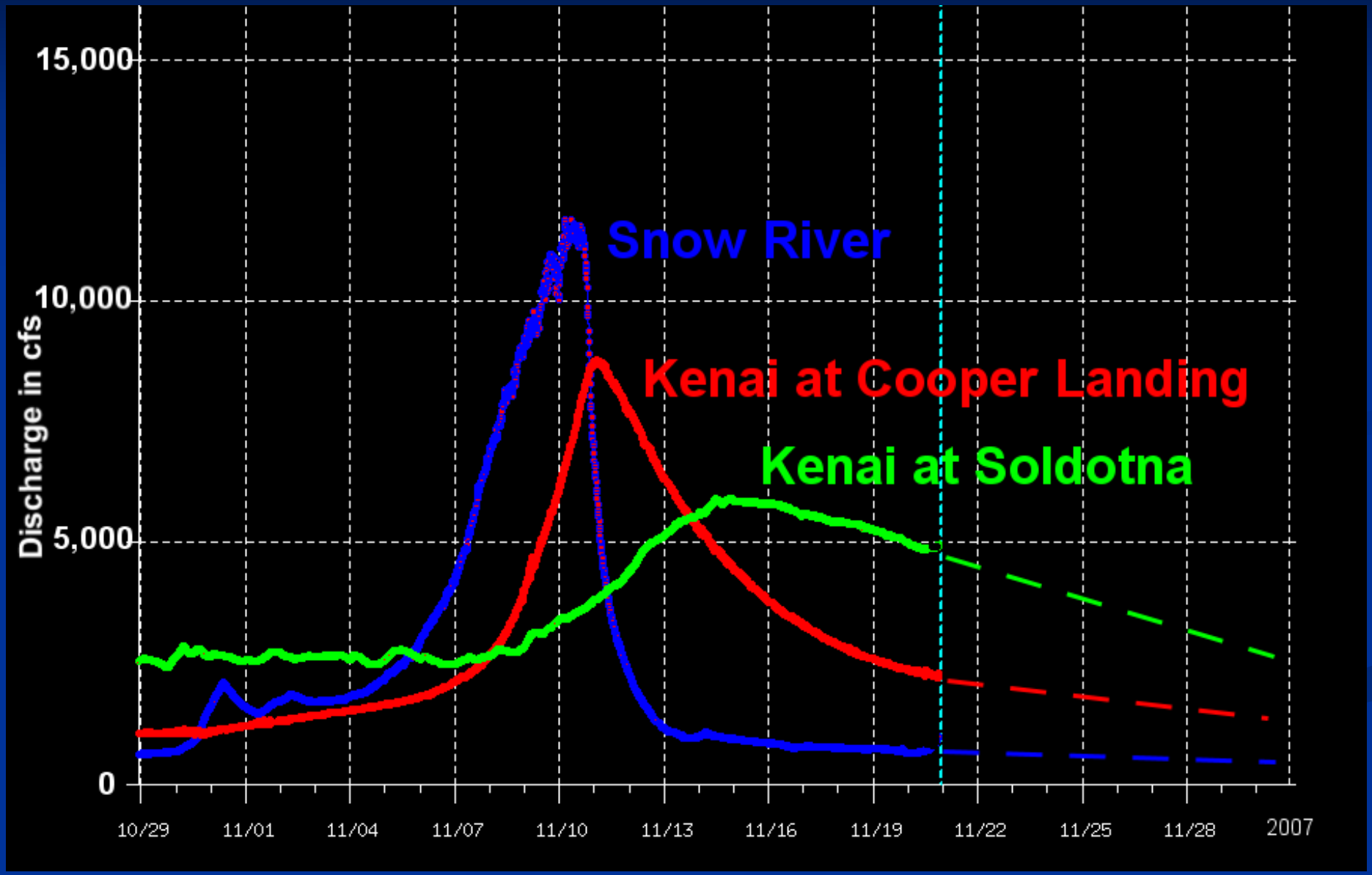


Snow Glacier Dammed Lake 2007

CAP photo on 11/5/07

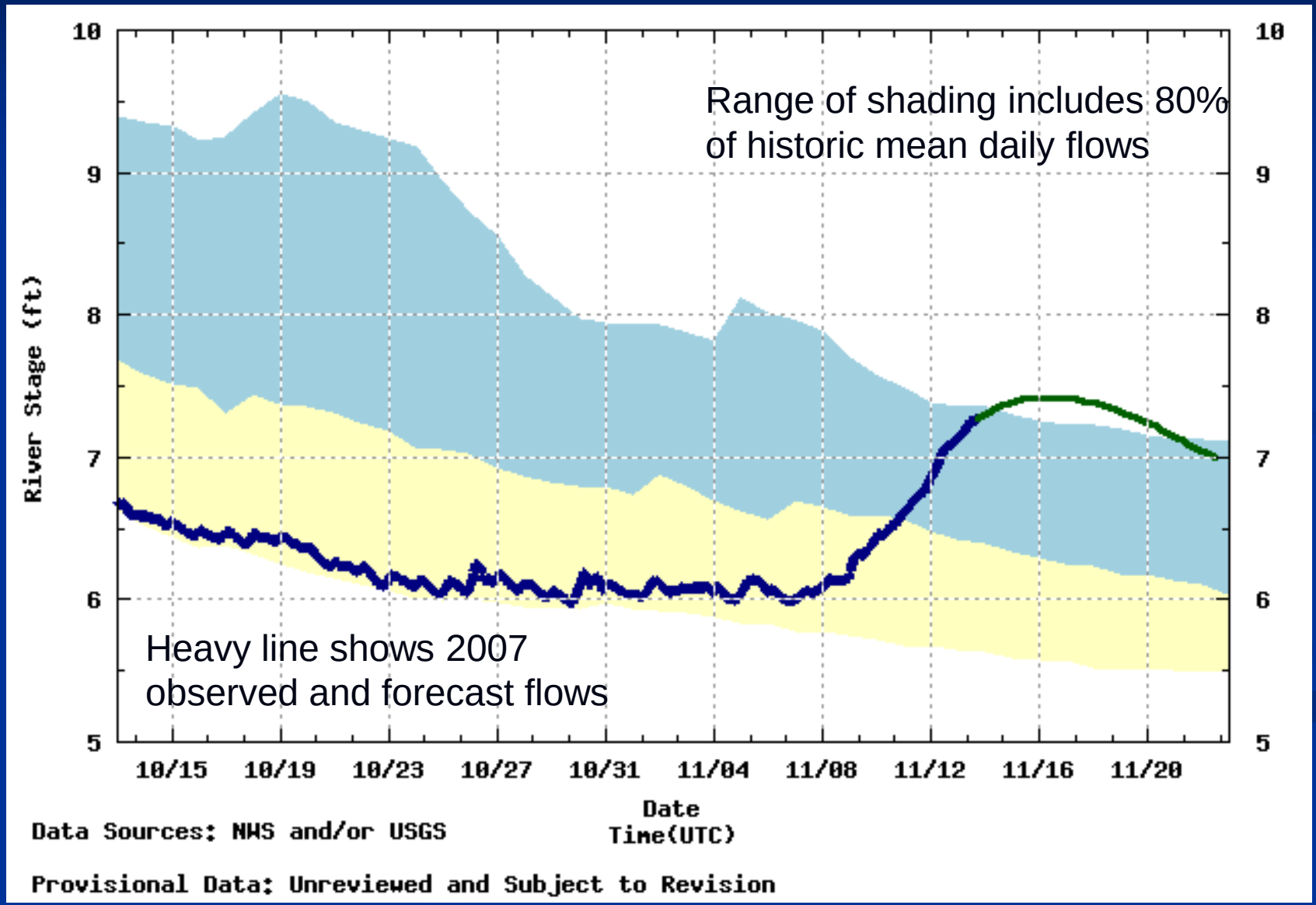
CAP photo on 9/10/07

Snow Glacier Dammed Lake 2007

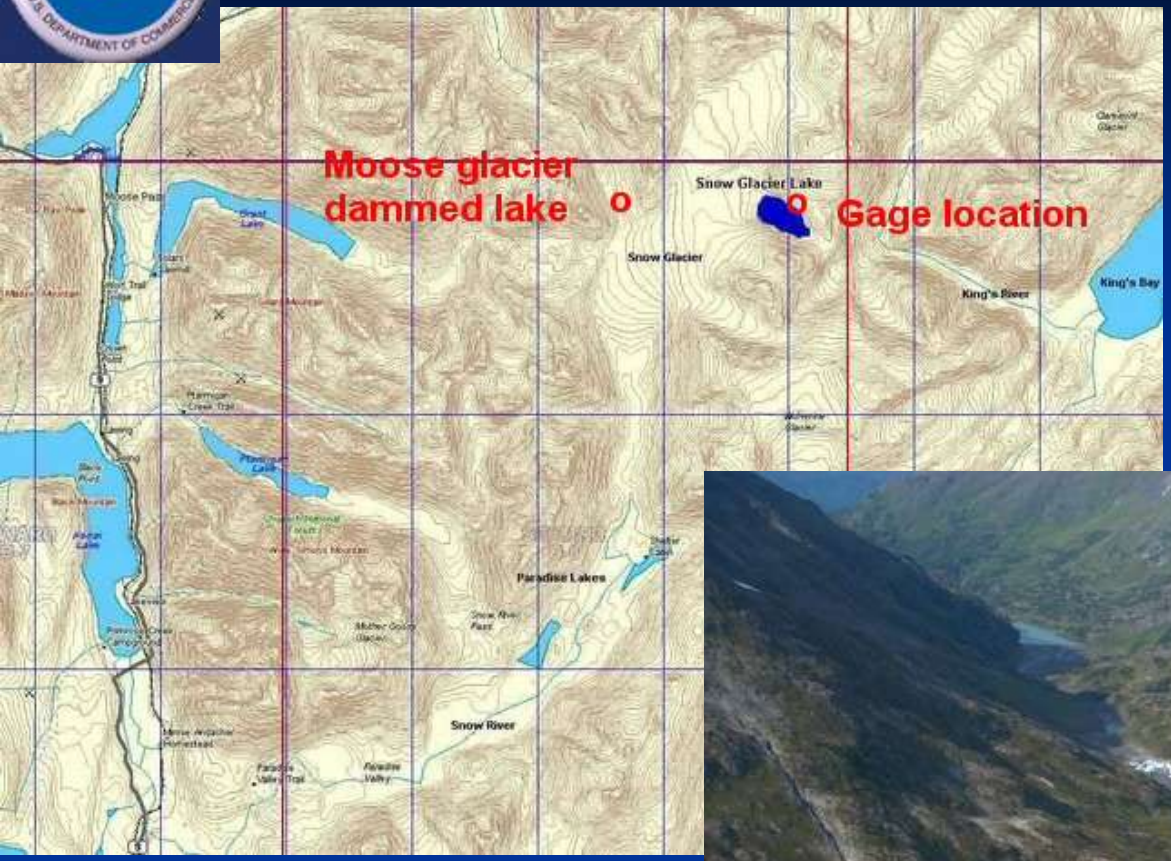


Glacier Dammed Lake Release Timing

Mean daily flow statistics and 2007 data for the Kenai River at Soldotna

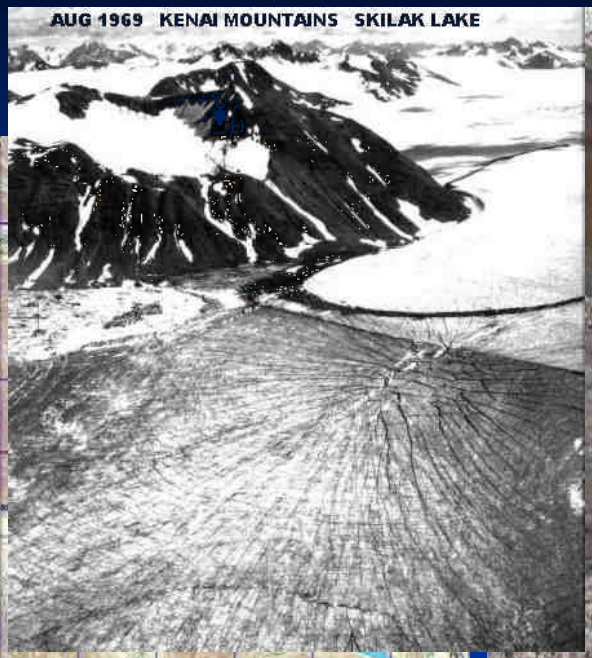


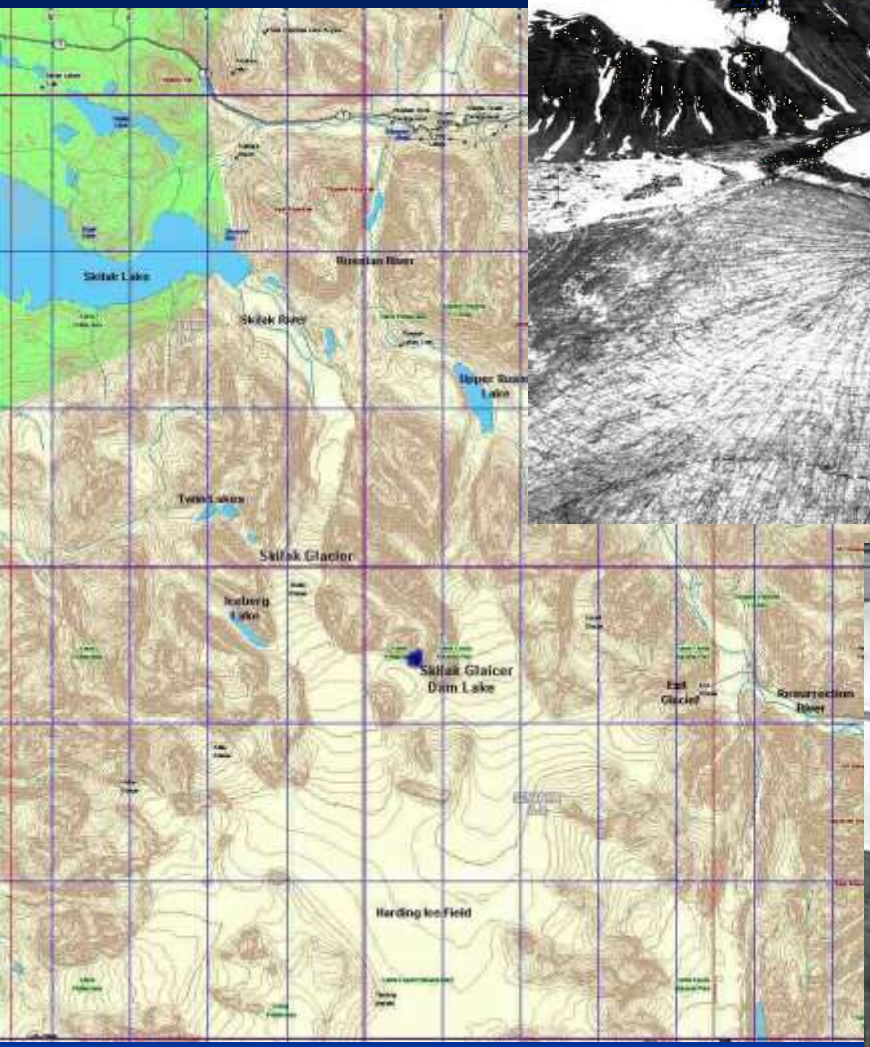
Moose Glacier Dammed Lake



- Small volume
- Summer release
- Little downstream impact

Skilak Glacier-Dammed Lake

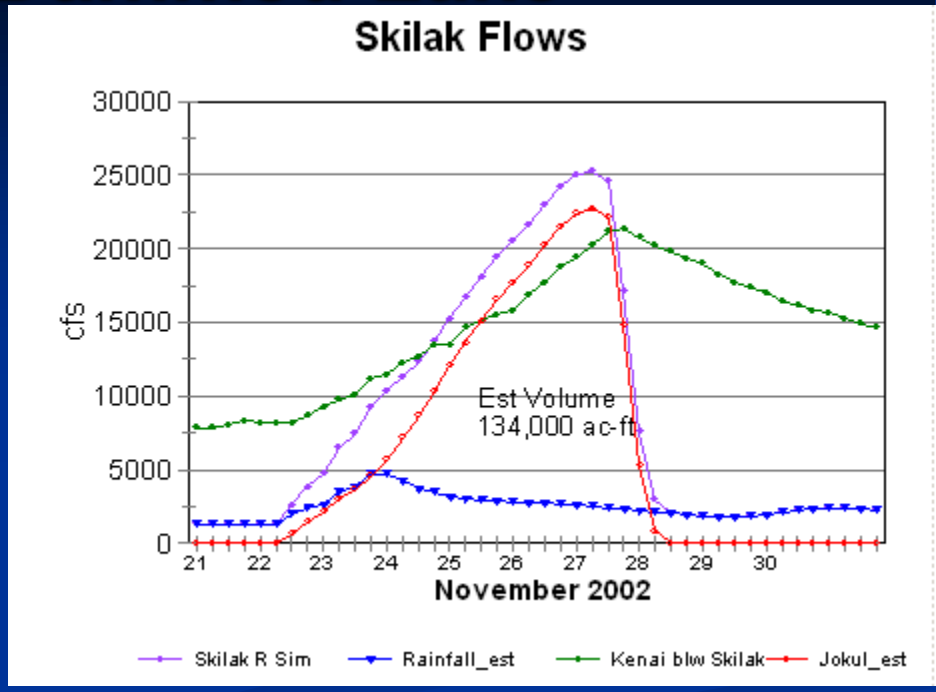




Lake releases sub-glacially

Skilak Glacier Dammed Lake

- Skilak glacier dammed lake volume is roughly 50,000 - 150,000 acre-ft
- Equivalent to 5-15 inches of rain over the entire Skilak River basin
- Lake takes 5-12 days to drain
- Causes 1-4 ft rise on lower river in open water conditions

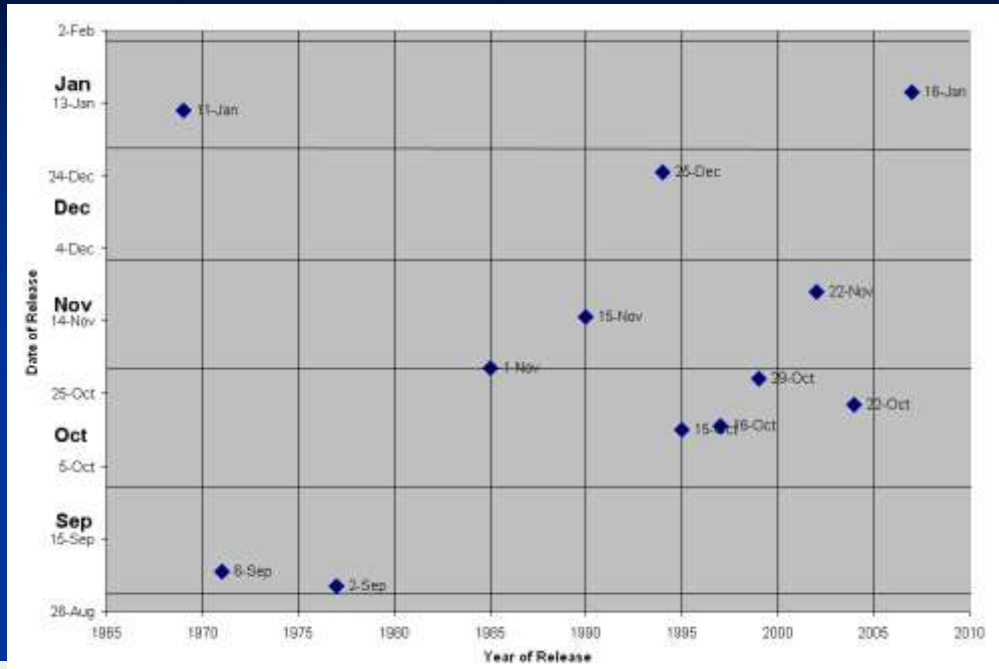


Skilak Jokulhlaup History

Not as well documented as the Snow GDL

Known Release History

January 1969*
September 1971
August 1974
September 1977
Late 1979
November 1985
November 1990
January 1994
October 1995
October 1997
November 1999
November 2002
October 2004
January 2007*



January 1969

January 1969

*Events that caused ice jam flooding

Skilak Release in January 2007

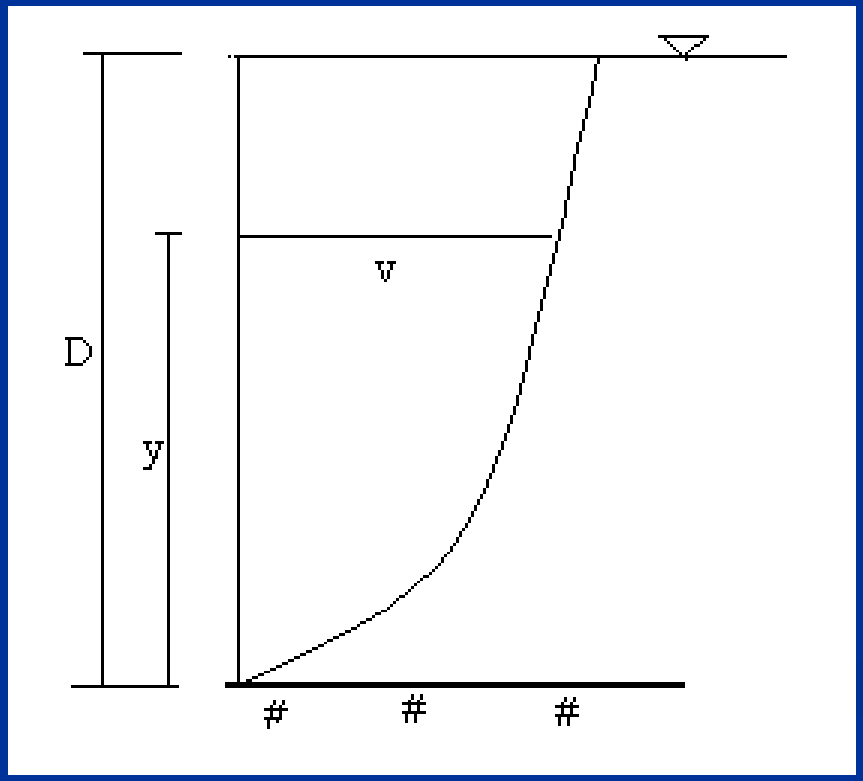
- release began on January16th
- crested on 27th after 3.8 ft rise at Skilak Lake
- occurred when lower Kenai River had ice cover
- caused ice jam flooding from river mile 32 to below Big Eddy
- the river stage at Soldotna reached 20.00 ft, 1/28/07 when a jam formed 1/2 mile downstream of the Sterling Hwy bridge

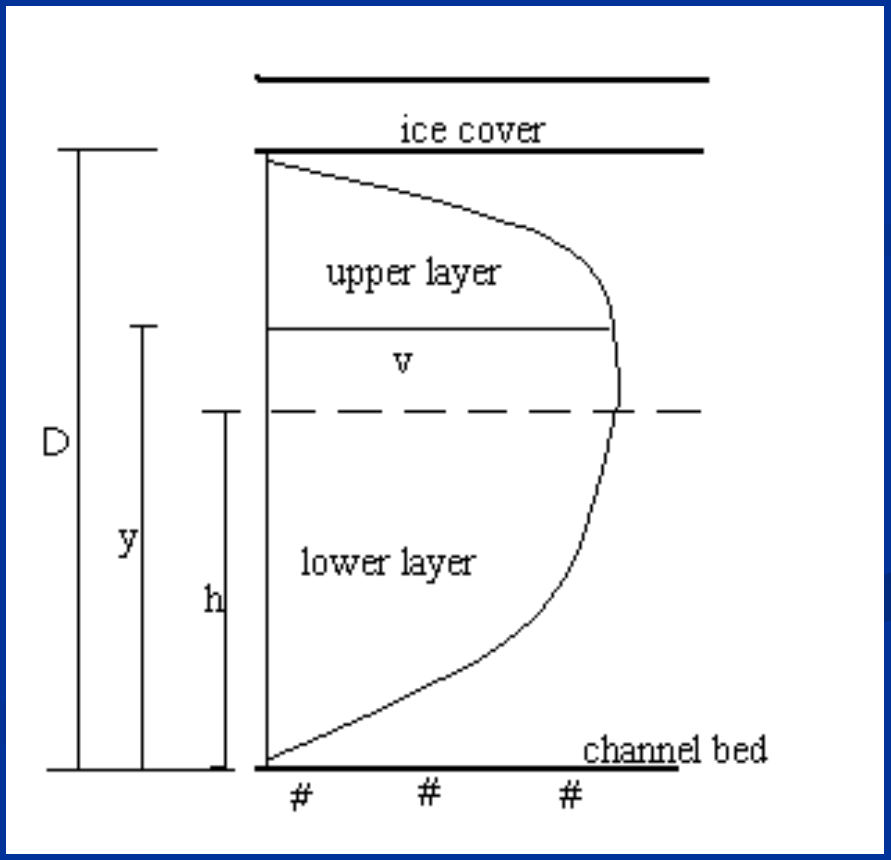
Lower Kenai River January 2007

Photos courtesy of Kenai Peninsula Borough Emergency Services

Ice Breakup Jam Flooding

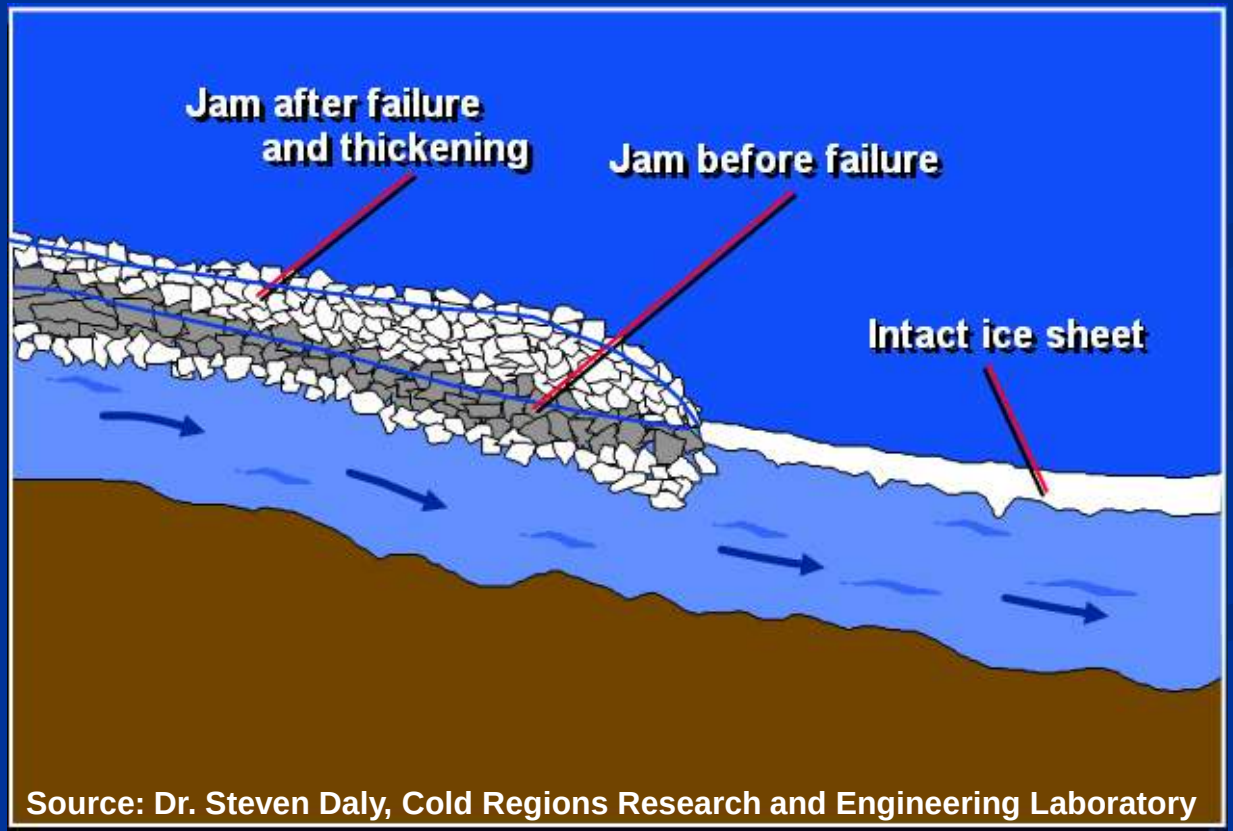
- The presence of ice slows the current
- Slower current requires more area for constant flow
- A backwater results up river from the ice cover
- Normally ice cover develops when flow is decreasing





Ice Breakup Jam Flooding

- When flow increases during a glacier dammed lake release, ice will lift and break up
- An ice run develops and moves down river
- When it runs into an ice cover down river, it could stop and jam, thickening the ice
- The ice cover is rougher and thicker, causing more backwater up river
- Further flooding likely due to increasing flow

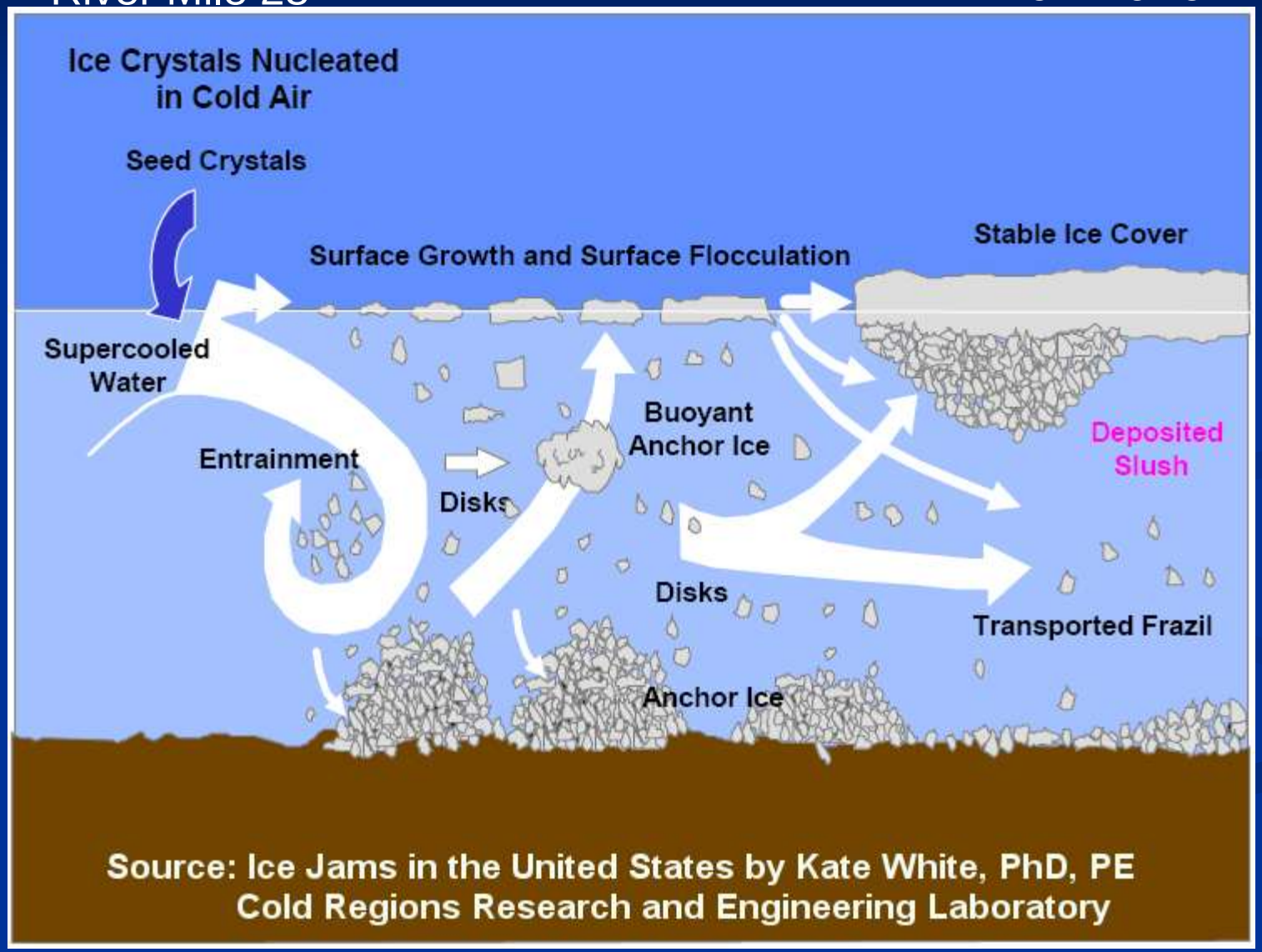


Source: Dr. Steven Daly, Cold Regions Research and Engineering Laboratory

Freeze-up Frazil Ice Jams

River Mile 28

River Mile 15



Thank You… Any Questions?

Web: http://aprfc.arh.noaa.gov